CMPT460/CMPT829
Computer Graphics
Department of Computer Science
University of Saskatchewan
December 18, 1996
9:00am
Three Hours

Answer all questions in an exam booklet.

1. Incremental algorithms:

   (a) Lines

   i. The algorithms given in class were only for those parts of the curve with slopes between 0 and 1. How are other parts of the curve drawn?

   ii. The implicit equation of a line can be given by

   $$ax + by + c = 0 \tag{1}$$

   What property of this equation is used in the incremental line drawing algorithm?

   iii. Give the initial value of the decision variable, as well as the two different increments, in terms of a, b, and c.

   (b) Parabolas

   For this subsection. Consider the class of curves defined by:

   $$y = ax^2 \tag{2}$$

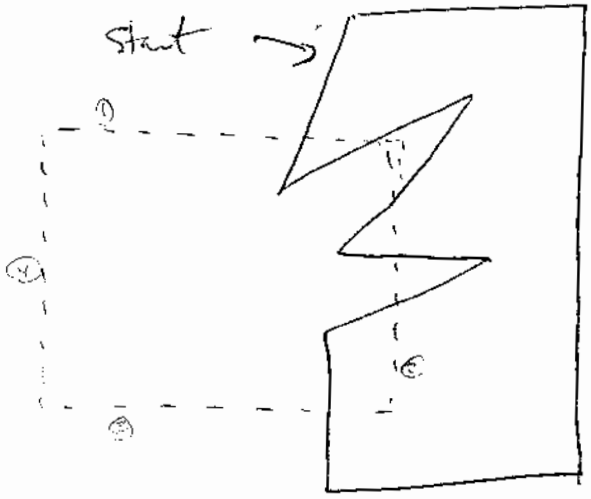
   i. This defines a set of parabolas. What symmetries would you take advantage of when drawing such a curve? For what segment(s) of the curve is the slope between 0 and 1? (Note that the derivitive of y with respect to x is $2ax$.

   ii. Rewrite the equation in implicit form. In which regions is the equation positive, negative and zero?

   iii. For positive integer values of a and for the region of the curve that starts at $x = 0$ and has a slope between 0 and 1, derive the starting values for the decision variable and the NE and E increments. How would you handle non-integral values of a?

2. Clipping

What is the output of the Sutherland Hodgeman algorithm, as studied in class, for the drawing below? The dotted line indicates a screen, the solid lines are straight polygon edges. Assume edges are clipped against the screen in the following order: top, right, bottom, left, and that the edges are traversed in counterclockwise order beginning with the edge indicated.



3. Geometric Transformations

(a) What is the homogeneous coordinate system?

(b) What is the inverse of a matrix T that translates points in the 3d homogeneous coordinate system by dx, dy and dz? Prove your answer.

(c) What is the inverse of a matrix S that scales points in the 3d homogeneous coordinate system by sx, sy and sz? Prove your answer.

(d) What is the inverse of a matrix R in the 2d homogeneous coordinate system that will rotate a point θ degrees counterclockwise about the origin? Prove your answer.

(e) Show that multiplication of scaling and rotation matrices commute when the scale factor is the same in all directions. That is,

$$S \cdot R = R \cdot S.$$

(f) Consider a point (x, y) in 2-space. Give a matrix that will rotate (x, y) so that it lies on the positive y axis.

(g) Cosmic Cadet wishes to create a graphical prototype for a Christmas tree ornament, based on a star catalogue. The star catalogue gives the position of bright stars in equatorial coordinates. Roughly speaking, this is the position the star would be on the Earth if it were not not so far away. Give an algorithm that will read in degrees longitude and latitude for 1000 stars and map each on on to a unit sphere centred at the origin. Assume that the final image can be rotated to give any view the user wants.

(h) The Three Little Pigs built three flat little houses on the X-axis, with the X-axis forming the floors. The lower leftmost corner of the first house was at $(0, 50)$ and the houses were 100 units apart. Assume that you have a computer image of this scene. Standing on the positive Z-axis, The Big Bad Wolf huffed and puffed and blew the houses down, so that they "fell over" and lie flat on the negative side of the Z-axis. Give the transformations necessary to modify your computer image to show the result.

(i) A computer scene contains, among other things, an airplane, with with its tail at $(20, 20, 20)$, its front propeller at $(30, 30, 30)$, and its wingtips at $(25, 23, 25)$ and $(25, 27, 25)$. Give the transformations necessary to equalize the y-coordinates of the wingtips.

4. Shading and illumination

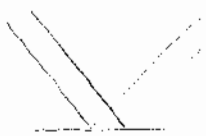
(a) Discuss the 3 factor illumination model of ambient, diffuse and specular illumination, stating the geometric imformation is needed to calculate each kind of illumination, and what qualities each kind of illumination brings to the image.

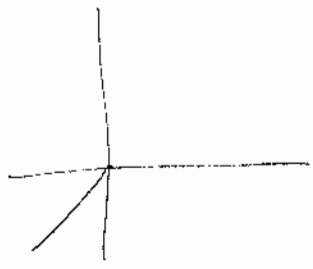
(b) What is meant by "interpolated" shading? Giving two examples of interpolated shading algorithms and describe how they work.

(c) You are asked to create an image where most of the objects have rectangular surfaces, except all edges are rounded slightly. You first represent the object with rectangles, but find that it is too harsh looking. Describe how you might shade such a scene without the complex geometry of curved surfaces.

(d) Discuss two ways to implement shadows.

(e) What is radiosity and how does it improve the three factor illumination model?





5. Choice: Discuss one of the topics below in some detail:

(a) depth of field

(b) motion blur

(c) hidden surface elimination

(d) particle systems

(e) Bezier, Hermite and B-splines

(f) CIE, RGB, CMY(K),YIQ and HSV colour models